

ON SOME *PAUROPODA* FROM NEW SOUTH WALES.

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(Plates lxx.-lxxi.)

At the end of May of this year (1914), I first recognised two individuals of a species of *Pauropus*, while overhauling a day's collections of *Collembola*, *Thysanura*, etc., under the microscope. On revisiting the locality in which this material was collected, I was easily able to find the same species in very considerable numbers, as well as a second species which was much less numerous. Both were found under bark lying upon the clay soil in forest-country at Archbold's Hill, Roseville. During June, I collected many specimens, some of which were kept alive in small tubes containing a little damp soil and pieces of bark, while others were preserved. For fixation, I used Carnoy's Fluid, which I subsequently found to have been considered satisfactory by Kenyon (1895). In many specimens fixed in this fluid, however, I found that there was a tendency for the cuticle to swell up away from the muscle-layers, causing considerable distortion. Believing this to be due to the large proportion of acetic acid, I later tried a modification, adding one per cent. of acetic acid to a mixture of two parts of 95% alcohol with one of chloroform. This mixture preserved the animals without distortion, but I have not yet cut any sections, so that I cannot vouch for the histological elements. Specimens fixed in hot aqueous sublimate-acetic were also preserved without distortion, and this fixative may prove satisfactory, as the cuticle is very delicate.

Late in June, I found the same two species at Broken Bay, in company with other species described later, which included a member of the remarkable genus *Eurypauropus*. These were all found under stones on damp ferny banks, where outcrops of shale

occurred among the sandstone. I was not successful in finding any on the sandstone-soil, which would not seem to retain sufficient moisture to afford a suitable habitat for these delicate little myriapods.

Pauropus is an active little creature, easily distinguished by the unaided eye from the lipurid *Collembola*, the only things with which it might otherwise be confused, by its markedly narrow anterior end, rapid movements, and rigid body, which is only rarely flexed from side to side. From observation of those which I have in captivity, I am quite confident that they are humus-feeders, as has already been surmised; for I have frequently watched them, under the microscope, browsing upon particles of soil on which I could distinguished nothing definite in the way of food. Those in captivity laid eggs rather freely, some of which I allowed to hatch out, while the majority were preserved. I hope to be able to obtain sufficient material to ascertain something of the embryology of the Order, which is unknown; but as, even if sufficient material be forthcoming, I shall not have the opportunity, for some time to come, of working at it, I have thought it advisable to publish descriptions of the forms found, of the post-embryonic stages, and some discussion of the segmentation.

The morphology of the adult forms has been well studied by Schmidt (1895), and Kenyon (1895). Of the post-embryonic stages I have very plentiful material, but I prefer to defer an account of the minute structure of these until such time as I am also able to give an account of the embryonic stages.

Pauropoda have hitherto been recorded only from Europe, the United States, Argentine, Chili, and Siam. The Australian species appear to show affinities to the South American rather than to the Asiatic forms.

Order PAUROPODA Lubbock.

Family PAUROPODIDÆ Lubbock.

Genus PAUROPUS Lubbock.

Hansen (1901, p. 349) gives the following diagnosis for the genus:—"The lower antennal branch has the anterior margin at

least slightly and generally somewhat shorter than the posterior, its anterior flagellum is shorter than the other, and the transverse diameter of the globulus is never shorter, and generally much longer than its stalk. The penultimate segment of the trunk with five pairs of dorsal setæ, two of which between the tactile setæ. The sternum of the anal segment has at least two pairs, and generally three pairs of setæ."

Of this genus, I have collected five species. One of these has been found in very considerable numbers; of a second, I have upwards of twenty individuals; while the remaining three are represented only by single specimens, two of which are described. The third is a form with a small anal plate bearing four short subequal processes, but is, unfortunately, not in sufficiently good condition to justify description.

I have not found any members of the second genus of the family, *Stylopauropus* Cook.

From the fact that five species have been collected in two localities only, it is reasonable to suppose that a considerable number will be forthcoming when these little creatures are looked for over a wider range.

Although it will certainly be necessary, at a later date, to divide the genus *Pauropus* into several genera, I have avoided splitting the genus in deference to Hansen's warning (1901, p. 341) that "many species must be discovered and studied before the characters of generic value can be pointed out with tolerable certainty."

PAUROPUS AMICUS, n.sp. (Plate lxx., figs. 1-11).

This species, which shares with *Stylopauropus pedunculatus* Lubbock, the distinction of being the largest known pauropod, was very plentiful among fallen timber at Lindfield during June and July. I found all stages, from egg to adult. It is of a somewhat social habit, being almost invariably found in colonies, which vary from half a dozen up to upwards of a hundred individuals. I have had a number in captivity, in small tubes half-filled with damp soil and I find, like Lubbock, that they are engaging little creatures to watch. They spend a great deal of their time cleaning their ap-

pendages, commencing with the antennæ, which are hauled down by a vigorous curling of the corresponding first leg about them, and drawn rapidly across the mouth; and proceeding on to each pair of legs in turn, the limbs being systematically washed from coxa to tarsus. The attitude assumed, in cleaning the extended hinder limbs, is amusingly reminiscent of the same process in the domestic cat.

The general form is robust, widest and highest at the fifth dorsal shield, and tapering gradually forwards and abruptly backwards. The whole cuticle is minutely pilose, the pubescence being a little stronger on the head, dorsal shields, and posterior legs. The anterior has the two basal joints short and subequal, the third about twice the length, the fourth longest, and swollen distally. The lower ramus is about two-thirds as long as the upper, and but little wider. Its anterior flagellum is less than half the posterior, and is borne on the truncated anterior corner. The basal unringed portion of the flagella is short. The globulus is small, and almost sessile. The upper ramus has its flagellum about one-fifth longer than the posterior flagellum. On the dorsal surface of the head, the "eyes" are widely separate, their inner margins being on a level with the bases of the fourth antennal segments.* There are three cylindrical hairs on either side, behind "eye"; a fourth hair of similar character projecting laterally in front of these. Mid-dorsally, in front of posterior margin, a pair of slightly club-shaped hairs; in front of these a row of four, similar; in front of these, a pair, similar, with a pair curved-cylindrical, laterally; before these, a row of six, then a median hair projecting forwards between bases of antennæ, all definitely club-shaped. The first dorsal shield is hardly wider than the head, the following shields gradually widening to the fifth; sixth narrower, with the rounded anal segment projecting beneath it. The shields are almost straight along the anterior border, but broadly rounded behind. The first bears a row of four hairs along the anterior border, the outer pair being cylindrical, not clavate; and a row of four clavate hairs along the posterior border. The second has a row of four clavate hairs in front of the middle, and a similar row close to the posterior

border; with a pair lateral and longer, midway between these two rows; and a second pair, cylindrical and twice as long, in front of and inside the tactile setæ, which are in the antero-lateral corners. The third and fourth shields have six hairs along hind border, all of the same character; and six hairs across the middle, the outer pair slightly longer. The second pair of tactile setæ is just in front of, the third pair just behind, the anterior row. The fifth shield has four hairs on the posterior border between and behind the tactile setæ; a pair lateral in front of these; and a row of six across the middle, the outer pair almost twice as long as the others. The sixth shield has a pair of hairs in the middle; a pair lateral behind these; and a pair close to the posterior border, between the tactile setæ, which are at the postero-lateral angles. The tactile setæ are delicately plumose almost to their bases, the last pair being longest. The rounded anal segment ends posteriorly in a button-like process, in front of which is a row of four clavate hairs, with a longer curved pair laterally. Below, it bears a pair of cylindrical plumose hairs, slightly swollen at the distal extremities, about the middle of its length; the styli long, with the distal half thinner than the proximal; and a pair of short, curved, club-shaped hairs, one outside each stylus. The anal plate is deeply cleft medianly, with four processes in one plane, the outer pair short, cylindrical, and reaching to the suture of the inner pair; the latter with sutures running diagonally inwards and backwards, the part behind the suture being precisely like the ordinary clavate hairs, with the inner face flat, the outer curving outwards distally. On the ventral surface, the twelve segments are completely marked off by transverse sutures less distinct laterally, cutting off a series of dicebox-shaped sternal areas. The copulatory appendages of the male are conical, extending without setæ to the hind border of the somite. The genital opening of the female is unpaired, and situated to the right of the midline. The rudimentary limbs of the first somite each bear two biramous hairs, the inner branches being reduced, and having a cylindrical process articulated distally. The penultimate legs are longest. The first leg has a cylindrical curved hair on the anterior face of the tibia, and a similar very short one

almost at the claw of the tarsus. The succeeding legs have similar hairs, and, in addition, a hair like that of the tibia upon the metatarsus. In the ninth leg, the metatarsal hair is present, and there is a distinct indication of division on the inner side of the tarsus at a little more than half its length. All the legs have biramous hairs upon coxa and trochanter. In the first eight, one branch is much reduced, with a very short cylindrical process articulated distally; the ninth having subequal branches. The anterior legs are distinctly three-clawed, the median longest; posterior legs with the anterior branch of the empodium apparently clawless, and the posterior claw almost as large as the median.

The sexes are equal in size. The length varies from 1.5 to 1.7 mm. in sexually mature individuals; the breadth averaging 0.4 mm.

Loc.—Lindfield: Broken Bay.

The form of the anal plate at once places this species in connection with three Chilian forms described by Hansen, *P. robustus*, *P. intermedius*, and *P. spectabilis*; but it shows no very close relation to any of these species.

PAUROPUS AUSTRALIS, n.sp. (Plate lxxi., figs. 12-14).

Of this smaller and more slender species, I have taken about a dozen specimens at Lindfield, where it is much less in evidence than *P. amicus*, hiding between the laminae of barksheets, and only being brought to light by careful searching. At Broken Bay, it was the commonest species; and I captured about twenty individuals under stones in moist places.

The form is slender, the sides subparallel, only slightly diverging posteriorly. The cuticle shows a fairly long pubescence on the last shield, anal segment, and posterior legs; a slight pubescence on the fifth shield; and is smooth in front of that. The antenna has the lower ramus a little more than half the upper, its flagella subequal and symmetrically placed upon truncated angles on either side of the globulus, which is large and distinctly stalked. The upper ramus is distinctly narrower, and has its flagellum longer by one-fourth than those of the lower ramus. The basal un-

ringed portions of the flagella are short. The hair on the anterior border of the fourth antennal segment is long, extending as far as the globulus. All the hairs of the upper surface are longer and more cylindrical than in the last species. Between the bases of the antennæ, is a very short cylindrical hair, with a club-shaped hair below it. Round the front margin of the head, are six club-shaped hairs, flanked by a pair, one placed in front of each eye, a little smaller and not so plumose. Behind the front row, a submedian pair, then a row of four, then a submedian pair. Behind each eye, two longish cylindrical hairs. Sublateral hairs, behind and below head, short and perfectly cylindrical. Hairs of dorsal shields as described by Hansen for *Pauropus* in general; all long, cylindrical and slightly swollen at tip. The first pair of tactile setæ are very coarsely plumose distally; the last pair much the longest, twice the width of shield, and with a meagre coarse pubescence. The anal segment has a pair of cylindrical hairs close to the midline at half its length, which reach to the posterior border; and a very short pair lateral to these; behind this row, there are two hairs on either lateral border, the anterior pair being much longer than the posterior. The segment ends in a slight rounded prominence. On the ventral surface, there is a pair of hairs on the middle of the segment, and two pairs on the lateral border, the posterior almost twice as long as the anterior. The anal plate has four processes in the same plane. The median incision ends square, separating the bases of the inner pair of processes, which are cylindrical, stouter than the outer, and have the distal third narrower and articulated. The outer pair spring from just behind the end of the median incision, diverge outwards, and are almost as long as the inner pair. The legs are rather short. The last has a long, tapering, plumose hair at the upper end of the tarsus; and a very short, stout, cylindrical plumose hair at the claw, with a similar one, slightly longer, on the tibia. Hairs on coxa and trochanter biramous. The tarsus seems to have the middle claw absent.

The average measurements of a number of specimens are 0.93 mm. long, and 0.16 mm. wide.

Loc.—Lindfield; Broken Bay.

This species seems to be most nearly related to *P. intermedius* Hansen, from Chili. The form of the antenna is very similar, and the anal plate, though differing considerably in detail, has the same general form.

PAUROPUS NOVÆ-HOLLANDIÆ, n.sp. (Plate lxxi., figs.15-16).

A single adult male of this species was taken under a stone at Broken Bay. The general form is fairly robust, the posterior end being considerably higher and wider than the anterior. The cuticle is apparently wholly without pubescence. The lower ramus of the antenna is a little more than two-thirds as long as the upper, and half as wide again. Its anterior flagellum rises from the truncated antero-lateral angle, and is but slightly shorter than the posterior, each being only a little more than twice the length of the ramus. The globulus and posterior flagellum are apical, the former fairly large, and with a stalk equal in length to its transverse diameter. Flagellum of upper branch about one-fifth longer than those of lower. Basal unringed portion of all flagella short and stout. The "eyes" are a little closer than their length. The hairs of the head have the usual disposition, and are cylindrical, slightly swollen towards apex. The hairs of the body are cylindrical and curved. The pair between the last tactile setæ, and those of the anal segment are all long. The tergum of the anal segment ends in a rounded prominence, below and beside which are the extremely short knob-like styli. Considerably lateral to these, on the posterior border, and outside the corresponding hairs of the sternum, are a pair of long hairs, one-third as long as the posterior tactile setæ. The sternum of the anal segment has a pair of long hairs, with swollen ends, on the posterior border, and a very short pair anterior to these, and nearer the midline. The sternum ends posteriorly in an oblong protuberance occupying one-third of the distance between the posterior hairs, its posterior border notched in the middle. The anal plate, the base of which is hidden under this projection, has two, long, triangular processes, with rather concave inner margins, not showing a transverse suture. The last pair of tactile setæ are twice as long as the third, and half as long again as the fourth. All

bear a very fine, fairly long pilosity. The penes are stout and large, reaching, without setæ, to the middle of the fourth segment. The last legs are longest. The hairs of coxa and trochanter are baton-shaped, none of them biramous, and those of the coxa much larger than those of the trochanter.

This specimen measures 0.75 mm. in length, by 0.15 mm. in breadth.

Loc.—Broken Bay.

This species occupies a somewhat isolated position. In the form of the antenna, and in the short, knob-like styli and long hairs of the anal segment, it shows affinity with *P. inornatus* Hansen, from the Argentine, but the form of the anal plate and sternum of anal segment differs considerably from those of the Argentine forms.

PAUROPUS BURROWESI, n.sp. (Plate lxxi., fig.17).

Of this species, a single immature individual, with eight pairs of legs, was available; but I have ventured to describe it on account of the remarkable form of the anal plate, which is only comparable with that of a Siamese form, from which, however, the present species is easily distinguished by several features. As I have only a single specimen, which, owing to its obstinate opacity, is difficult to describe in detail, I content myself with its outstanding features.

The antenna has both rami short, the lower extremely so, and only one-half the length of the upper. The former has its antero-lateral angle obliquely truncated, bearing the anterior flagellum, which is not quite one-half the length of the posterior. The upper ramus is short, its flagellum thrice its length, and one-fifth longer than the posterior flagellum of the lower ramus. The globulus is conspicuously large, as wide as the distal end of the upper ramus, with a stalk about one-half its diameter. All the flagella are much swollen distally, the last four or five rings being distinguished from the rest by a clearly defined central axis running through them, of the same diameter as the little terminal bulb, with which it connects. The anal segment and plate have very much the same general features as in *P. mortensenii* Hansen,

but differ in details. The dorsal setæ have the same peculiar arrangement and proportions, except that the submedian pair is at least as long as the lateral. The styli differ in being more curved in over the anal plate, and in having broadly spatulate ends. The posterior ventral setæ are situated upon protuberances, which are rather more oblong in shape than those of *P. mortensenii*, and the setæ themselves are not much more than one-half the length of the submedian dorsal setæ, and are a little swollen, not tapering, distally. The anal plate is generally like that of *P. mortensenii*, but the two processes are deeply incised on their inner margins a little behind the apices; and, behind these clefts, are a pair of rounded, rudimentary processes, a little dorsal to the plane of the plate.

The specimen measures 0.52 by 0.15 mm.

Loc.—Broken Bay, under a stone.

This species shows undoubted affinity to *P. mortensenii* Hansen, from the Gulf of Siam. This is a little remarkable in view of the fact that the other three species described, all show a closer relation ship to South American forms. But the number of described species is too small to allow of any profitable discussion of inter-relations.

Family EURYPAUROPODIDÆ Ryder.

Genus EURYPAUROPUS Ryder.

The single genus of the Family is characterised by the large development of the dorsal shields, the first of which projects forward beyond the anterior margin of the head, while the last similarly overlaps the anal segment. They are, in addition, so wide that the legs do not project beyond them, and are heavily sculptured, or ornamented with tubercles and spines, the usual hairs being absent. The tactile setæ are not inserted upon them, but either below or in lateral clefts.

EURYPAUROPUS SPECIOSUS, n.sp. (Plate lxxi., figs. 18-21).

Four specimens of this species were collected under a small stone on a mossy bank at Broken Bay, two adult males, and two immature individuals with five and six pairs of legs respectively.

The species has about the same proportions as other members of the genus. The dorsal surface is wholly covered by six dorsal shields. The first of these is strongly rounded in front, not so much so behind, and covers the legless and first leg-bearing segments. The head hangs free below it. Its border is entire. The second presents a narrower anterior portion, not so strongly chitinised, and passing insensibly into the articular membrane. At one-quarter of its length, it broadens out rectangularly, the first pair of tactile hairs projecting through notches in the angles. The third, fourth, and fifth plates are deeply cleft at about one-half their length, the clefts of the third being a little in front, of the fifth a little behind, that point. The sixth shield has the clefts far back towards the posterior border, and the portion behind the clefts very much narrower than that in front. The tactile setæ arise from the "pleuræ" just within the angles of these clefts, and are of the usual type, but much shorter than in *Pauropus*.

The dorsal shields are devoid of spines, but have a beautifully sculptured pattern. This is formed by a series of broad, raised ridges, which enclose sunken areas, usually triangular, but many of them irregularly quadrilateral. Where these ridges meet, there is formed a rosette-like structure, consisting of a central boss, separated by a circular groove from a broad raised ring in which are from twelve to sixteen radially elongated depressions. The enclosed depressed areas have a central irregular prominence, from which run six or more, radially directed, secondary ridges, which meet the primary ridges. The secondary ridges are never more than one-third as wide as the primary. Posteriorly, the shields are terminated by a row of rosettes; but this passes inside the lateral borders, which are formed by a thin, scalloped plate, divided into a series of platelets by raised ridges.

The antenna is a little remarkable. The lower ramus is a little more than twice as long as its width at the base, and its flagella seem to be rather upper and lower, than anterior and posterior. Of these, the lower, which would correspond with the anterior in *Pauropus*, rises from an extremely short, cylindrical process at two-thirds of the length of the ramus. Beyond this point, the

ramus is narrower by the width of this process, and the upper flagellum and globulus are borne apically upon the flat top of this narrower portion. The lower flagellum is about half the length of the upper; and the latter is, in turn, about three-quarters of the flagellum of the upper ramus. The upper ramus is thrice and one-half as long as broad, and its breadth is about equal to that of the distal portion of the lower. The two longer flagella have a basal unringed portion at least as long as the rami to which they are attached. The stalk of the globules, which is large, is about once and one-half as long as its transverse diameter.

I have found it extremely difficult to make satisfactory observations of the ventral surface, as I could not afford to injure my specimens; but I have finally been able to compare this species with Hansen's figures on all points except the anal plate, about the distal portions of which I cannot be certain. The tergum of the anal segment has the lateral hairs the same shape as, and longer than, the submedian; otherwise, it agrees with Hansen's figure. The sternum has a row of four hairs, the outer pair being stout, and slightly plumose distally; the inner pair delicate, shorter, and sharply ringed. The posterior ventral setæ are more than twice the length of the outer pair, and are only shortly plumose distally. The anal plate is rounded basally, its sides narrowing slightly backwards, and passing into two long processes, which are separated from one another by a deeply incised cleft. A second pair of wing-like processes seem to lie dorsal to the main body of the plate. The distal ends of the main processes, I was unable to observe satisfactorily. As far as I can judge, they end as in the figure (Fig. 18), but it is quite possible that they may show some such structure as that observed by Hansen.

The legs are very short, and none of them have a metatarsus. The hairs of coxa and trochanter are both like that of the trochanter in Hansen's figure. The tarsus bears a single large claw, with a very fine, hair-like, second claw anteriorly. The second tarsal hair mentioned by Hansen, is not present.

The larger male measures 1.2 in length.

Loc.—Lobster Beach, Broken Bay.

Until the existing descriptions of European and American *Eury-pauropodidae* are verified and amplified, it is little use attempting to discuss the affinities of the species here described. As Hansen has pointed out, if Ryder's and Latzel's descriptions are correct, this species, together with that which he describes without naming, will have to be transferred to a new genus.

Types of the five species, described as new, have been deposited in the Australian Museum, Sydney.

Development of *Pauropus amicus*.

The first eggs seen were laid by females captive in tubes, but I was later able to find them in the field. In both cases, the eggs were laid in groups of from twelve to twenty-four, loosely attached to pieces of bark, apparently by some sticky secretion of the oviducal walls.

The egg is perfectly spherical, pearly white, and 0.17 mm. in diameter. Under low power, the outer membrane, which is opaque, appears covered with minute pustulations. These, under a higher magnification, show as short, flat-topped, cylindrical processes. No sections have been cut, but observations made while the eggs were passing through fixing fluids, would appear to indicate that the embryonic development resembles that of the Diplopoda. The egg proper, which has, after fixation, only two-thirds of the diameter of the outer membrane, shows, in iodised alcohol, an appearance of total segmentation, but no nuclei are visible at the surface, so the areas probably represent yolk-pyramids. At a later stage, a distinct ventral flexure is observable. At the twelfth day, the outer membrane breaks, and the embryo bursts out in part, its anterior end being free, while the posterior end is still enclosed in the membrane. The embryo is covered by an embryonic membrane, which bears outgrowths covering the antennæ only; the three pairs of legs, though visible inside, making no impression on this second cuticle. The cuticle is covered with long, tapering, cylindrical, hair-like outgrowths; and is definitely segmented, the segments being more numerous than the apparent somites of the hexapod larva, and showing no trace of fusion. The embryo remains motion-

less, in this condition, for three further days; and then, by the splitting of the second cuticle through the whole of its length dorsally, issues out as an actively moving, hexapod larva. Up to this stage, the eggs have been constantly guarded by the female; but, from this on, the young are left to themselves, and move about actively.

The six-legged larva has an antenna with two basal joints only, the distal telescoped into the proximal, so that a line, looking like a division of the latter into two, is visible. The lower ramus of the antenna is a little more than one half as long as the upper, and bears subequal flagella, the anterior slightly longer. Both are less than one-half the length of the upper flagellum. The hairs of the head are arranged much as in the adult, but are all of the same baton-shaped character. There are two behind each eye, and a pair on either side of the midline close to the hind margin; in front of these, a row of four, the outer pair slightly behind the inner; in front, a pair, with a pair marginal at the same level; in front of these, a row of six, and two in the midline, one above (behind) the other, between the bases of the antennæ. Three dorsal shields are present. The first covers the legless and first leg-bearing segments, and is without tactile hairs; the second covers the remaining leg-bearing segments, and bears a pair of tactile setæ, plumose through their distal three-fourths, projecting outwards and forwards from about one-fourth the length from the anterior end; the third covers the pre-anal and part of the anal segment, and bears a pair of similarly plumose tactile setæ projecting backwards from the postero-lateral corners. The first shield has a row of four hairs in front of the hind margin, and a hair in each antero-lateral angle, well on the shield; the second has a row of four along front and hind margins, the tactile setæ being just behind the antero-lateral pair; the third has a pair towards the middle, a little behind the anterior margin, a pair a similar distance in front of the posterior margin, a pair lateral, longer, midway between them, behind which are the tactile setæ. The anal segment ends in a button-like process, similar to that of the adult, overhanging the anal plate. Its three pairs of hairs are situated

close together, and are proportionately long, the submedian being very long. The styli are fairly long, and incurved. The anal plate (Fig. 8) differs from that of the adult in that the clavate hairs, which terminate its inner processes, have inner rudimentary branches. The first and third legs are five-jointed, the second having a metatarsus marked off. The hairs and claws are as in the adult, except those of coxa and trochanter, which, with the two pairs on the leg-rudiments, are all biramous, with subequal cylindrical branches, slightly swollen distally, the inner distinctly articulating with the outer (Fig. 6). These hairs are all proportionately longer than in the adult. There are two pairs of hairs on the sternum of the anal segment. Six segments are completely differentiated ventrally. The whole cuticle is minutely pilose. The wall of the midgut is, even at this stage, already full of lime-crystals. In the hexapod condition, the larva grows in length from 0.33 mm. at hatching, to upwards of 0.5 mm.

The ten-legged larva ranges in length from a little over 0.5 up to 0.7 mm. It has four dorsal shields, the fourth being interpolated between the second and third of the previous stage, and bearing an additional pair of tactile setæ at the middle of its length, projecting laterally. This shield covers the two added pairs of legs. The antenna has three basal segments. Eight segments are well marked ventrally.

The twelve-legged larva ranges in length from upwards of 0.7 to over 0.9 mm. The antenna has three basal segments. The anterior flagellum is less than one-half the length of the posterior, which is about four-fifths as long as the flagellum of the upper ramus. There are five dorsal shields, the first four with the usual two rows of clavate hairs, the fifth with both rows very far back. There are four pairs of tactile setæ; the first, second, and fourth as in the last stage, the third projecting backwards from a little behind the middle of the fourth shield. The biramous hairs of the limb-rudiments and basal joints of the legs have assumed the adult clavate form, but all still have two subequal branches. Ventrally, the segmentation is normal as far back as the third shield (fifth legs); behind which, there is no suture until that of the anal segment is

reached. This undivided area certainly includes two segments, the pre-anal and that of the sixth legs. Possibly another segment is represented between these, but, provisionally, the number of body-segments may be set down as nine.

One individual, observed alive within a day of moulting, showed the antennæ and hairs of the next stage through the cuticle. The basal segments of the antennæ were filled with the flagella of the new antennæ. The clavate hairs of the head, for the new stage, were behind those of the old. The new hairs of the first four shields directly underlay the old. In the fifth shield, however, the new hairs of the first row were well in front of the old, and of the second row slightly in front.

I had hoped, by means of this individual, to prove definitely that no stage with fourteen legs occurred. But, although it moulted successfully a day after the above observations were made, it was, unfortunately, so badly crushed between two pieces of bark in removing it from the tube, that the number of legs could not be made out. From observation on very plentiful material, in which all the other stages are represented by many individuals, I am quite satisfied that no such stage does occur; and a careful examination, under a strong lens, of many more specimens in the field, has failed to produce it.

The sixteen-legged larva ranges in length from a little under 1 mm. up to 1.3 mm. The antenna has four basal joints, and its rami and flagella have assumed the adult proportions. The genital aperture is present in the female; and the penes in the male. There are five dorsal shields, and four pairs of tactile setæ, as in the previous stage; but the tergite of the anal segment is much larger and more prominent. Ventrally, there are eleven distinct segments plainly visible. Of these, the first eight are covered by the first four dorsal shields; the ninth and part of the tenth underlie the fifth; while part of the tenth seems definitely to underlie the tergite of the anal segment. In other respects, this stage does not differ from the adult.

Segmentation.—The relation of the dorsal shields to the segments of the body has been variously interpreted; and hardly any two current textbooks of zoology will be found in agreement on the point. Schmidt (1895) and Kenyon (1895) have, however, definitely established the existence of a head and twelve segments; the first of which, Schmidt, following Latzel (1880), calls the hind-head segment; while Kenyon considers it to be the first trunk-segment. *P. amicus*, owing to its large size, and the complete demarcation of its segments ventrally, is a favourable form for the study of the segmentation. I have, therefore, added a brief note on this subject.

I agree with Kenyon in dividing *Pauropus* into a head and twelve trunk-segments. On the segmentation of the head, Kenyon writes (1895, p. 82)—“In the triangular head, so far as one may be able to judge from the number of appendages, there are three segments, corresponding to the antennæ, the mandibles, and the maxillæ. . . . But . . . there is other evidence of cephalic segmentation and possibly there are more segments in the Chilognath head and in that of the Pauropoda than the number of appendages would indicate.” Kenyon claims, for the Pauropoda, a close affinity with *Polyxenus*, in which Carpenter (1905, p. 478) has shown maxillulæ to be present. It is a matter of some doubt, therefore, whether the mouth-parts of *Pauropus* consist of only two pairs of appendages. From an examination of the dorsal surface of the head of *P. amicus*, I would suggest that at least five segments are present. Behind the antennary segment, are four rows of clavate hairs. On the trunk, each such row indicates a segment. In addition, there is, in the young stages and in some adult specimens, a distinct indication of a suture between the antennæ and the anterior row of hairs; and of a second between the second and third rows of hairs; which would give two dorsal plates, each bearing two rows of hairs, strongly suggesting a comparison with the dorsal shields of the trunk.

In connection with the trunk, the statement is usually made, that eight segments fuse to form four double segments. It seems to me, however, that all six dorsal shields have an equal value, each bearing two rows of hairs, and each being in relation to two underlying

segments. The first covers the first and second segments, *i.e.*, that with only limb-rudiments, and that bearing the first legs. The next four each cover two leg-bearing segments. In the case of the last, though the anal segment projects freely behind, its anterior border usually passes under the shield; and, in a lateral view of *P. amicus* (Pl. lxx., fig. 10) this insertion is very obvious. This interpretation would have the advantage of giving a uniform series of double tergites, and may possibly, as has been indicated above, also apply to the head.

The contention, that the sixth shield is of a double nature, is supported, to some extent, by the condition of that shield in *Eury-pauropus*, the posterior part being marked off from the anterior by two lateral clefts. Ryder (1879, *a*) claimed these clefts as evidence of the double nature of the shields; but Kenyon (1895, p. 91) doubts the segmental significance, and suggests that the clefts are formed "merely because the tactile hairs would otherwise be prevented from projecting upwards in a position to be of greatest use to the animal." I am inclined, however, to agree with Ryder. The clefts are not necessary for the tactile setæ, as these might just as easily be situated on the shields, as they are in *Pauropus*.

The supposed diplopod condition of the Pauropoda does not seem to me to be in any way comparable with that of the millipedes. The double segments are certainly formed in a totally different way, and, in the case of the Pauropoda, fusion is confined to the dorsal shields. This fusion, I consider to be purely secondary, and to have been brought about by a series of thickenings of the dorsal cuticle, which were, at first, segmental, as we can see in *Brachypauropus*; and which, later, without segmental significance, fused in pairs. *Pauropus* is an animal with twelve, distinct trunk-somites, the value of which is wholly independent of the dorsal shields.

Nevertheless, the affinities of the Pauropoda are pretty certainly with the Diplopoda, and they are possibly best regarded as an equivalent Order. It seems unnecessary to raise them to Class-rank (Pocock, 1911); and not yet justifiable, in the light of present knowledge, to reduce them to the rank of a Suborder, sharing, with *Polyxenus*, an Order, Protodiplopoda (Kenyon, 1895).

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EXPLANATION OF PLATES LXX.-LXXI.

Plate lxx.

Pauropus amicus.

- Fig. 1.—♂, from below.
 Fig. 2.—♂, from above.
 Fig. 3.—Biramous hair from leg-rudiment.
 Fig. 4.—Biramous hair from trochanter of first leg.
 Fig. 5.—Biramous hair from trochanter of ninth leg.
 Fig. 6.—Biramous hair of hexapod larva.

Fig. 7.—Anal plate.

Fig. 8.—Anal plate of hexapod larva.

Fig. 9.—Anal segment, from above.

Fig. 10.—Posterior end, from the side.

Fig. 11.—Antenna.

Plate lxxi.

P. australis.

Fig. 12.—Anal segment, from below.

Fig. 13.—Anal segment, from above.

Fig. 14.—Part of antenna.

P. novæ-hollandiæ.

Fig. 15.—Anal segment, from below.

Fig. 16.—Antenna.

P. burrowesi.

Fig. 17.—Anal segment, from above.

E. speciosus.

Fig. 18.—Anal plate.

Fig. 19.—Antenna.

Fig. 20.—Penes from the side.

Fig. 21.—Detail of sculpture.